University of Southern California

An Architecture for Multimedia Connection Management

Eve M. Schooler and Stephen L. Casner

ISI/RR-92-294

August 1992

INFORMATION SCIENCES INSTITUTE

310/822-1511

4676 Admiralty Way/Marina del Rey/California 90292-6695

ISI Research Report
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This research was supported by the Defense Advanced Research Projects Agency under Ft. Huachuca contract number DABT63-91-C-0001, entitled "Gigabit Network Communications Research". The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency, the Department of the Army, or the U.S. Government.

REPORT DOCUMENTATION PAGE

FORM APPROVED
OMB NO. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
August 1992

3. REPORT TYPE AND DATES COVERED
Research Report

4. TITLE AND SUBTITLE
An Architecture for Multimedia Connection Management

5. FUNDING NUMBERS
C-DABT63-91-C-0001

6. AUTHOR(S)
Schooler, E.M.; Casner, S.L.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USC INFORMATION SCIENCES INSTITUTE
4676 ADMIRALTY WAY
MARINA DEL REY, CA 90292-6695

8. PERFORMING ORGANIZATON REPORT NUMBER
ISI/RR-92-294

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
DARPA
3701 N. Fairfax Drive
Arlington, VA 22203-1714

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12A. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12B. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

What ingredients are needed to enable widespread personal teleconferencing over the Internet and NREN? The major focus of our work in the Multimedia Conferencing Project at ISI is on the design and implementation of protocols at a number of levels in the protocol stack; at the lower levels, real-time data communication services for the Internet in general; and at higher levels, a connection management architecture to facilitate connections among heterogeneous systems. In this paper, we confine our discussion to higher level issues: an overall connection architecture, a connection control protocol, and configuration management.

14. SUBJECT TERMS
Multimedia, teleconferencing, connection architecture, connection management, configuration management, connection control protocol

15. NUMBER OF PAGES
8

16. PRICE CODE

17. SECURITY CLASSIFICTION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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An Architecture for Multimedia Connection Management

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1 Introduction

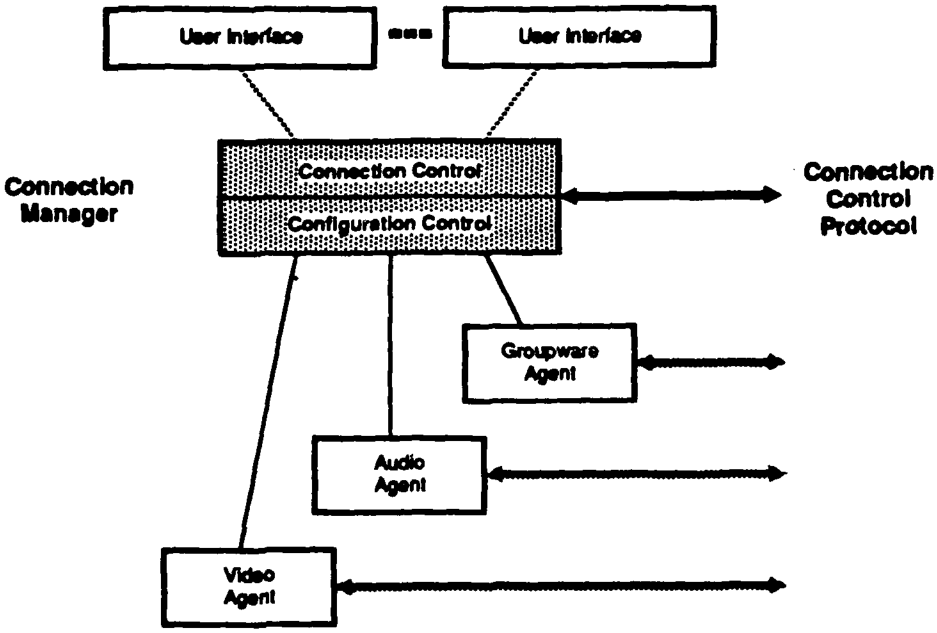
What ingredients are needed to enable widespread personal teleconferencing over the Internet and NREN? Certainly the integration of audio and video compression hardware into workstations is essential. However, network protocols are as critical to this goal. This is the major focus of our work in the Multimedia Conferencing Project at ISI. Toward this end, ISI and BBN have developed an experimental packet teleconferencing system that currently is operating at several sites on the Terrestrial Wideband Network, TWBnet [1], and has more recently been ported to the DARPA Research Testbed, DARTnet, for further experimentation. The system allows geographically separated individuals to collaborate by combining real-time packet audio and video with shared computer workspaces, sometimes called *groupware*.

We are designing and implementing protocols at a number of levels in the protocol stack: at the lower levels, real-time data communication services for the Internet in general [2–4]; and at higher levels, a connection management architecture to facilitate connections among heterogeneous systems. In this abstract, we confine our discussion to higher level issues: an overall connection architecture, a connection control protocol, and configuration management.

2 A Connection Management Architecture

We have designed a framework for applications such as teleconferencing that require the establishment of multiple participant, multiple media sessions. We propose that such applications be constructed as shown in the diagram below. The central component that orchestrates the multiparty, multimedia connections is the *connection manager*. Conceptually, it is separate from user interfaces (UIs) to the system, which sit above it offering services up to the user and relaying requests down from the user. By separating the connection manager from the user interface, conference-oriented tools avoid duplication of effort; this encompasses management of participation, authentication, and presentation of coordinated UIs. This is along the lines of Swinehart's switching kernel [5] and is related to Lantz' and Lauwers' models for UIs that endow programs with the ability to be multi-user [6]. The connection manager is also separate from underlying components, called *media agents*, which handle communication protocol decisions (transport and internetwork protocols) and the devices specific to each type of shared media (audio, video, groupware). This organization also allows the connection manager to convey timing information between media agents for inter-media synchronization.

We refer to this layered organization as the *connection management architecture*, since management of connections is the primary focus of the model and since the connection manager acts as the conduit through which control information flows between layers. Its modularity allows functionally-equivalent components to substitute for each other. Our current teleconferencing system is the forerunner to this architecture, but we have also drawn ideas from other connection management schemes [7–10]. While these schemes are diverse, each has suggested the need for a connection management abstraction. The emphasis of our architecture is to provide reliability across WANs, to accommodate heterogeneity, and to facilitate interoperability with other teleconferencing implementations.



Coordinated Management of Separate Services

3 The Connection Control Protocol

The Connection Control Protocol (CCP) is an application layer protocol used by connection managers to communicate among themselves. It is based on the protocol used by the Multimedia Conference Control Program (MMCC), which has served as both user interface and connection manager for the existing system [11]. The CCP is essentially a multicast, transaction-based protocol. It aims to provide reliable, group communication and to accommodate variability in request-reply response time due to WAN operation and to heterogeneous end system configurations. The specification for CCP has been drafted [12] and implementation is underway.

Conference orchestration is achieved through use of a distributed, peer-to-peer model. Peer connection managers reside on machines scattered throughout the Internet. Each connection manager acts as both client and server, notifying users of requests from other connection managers, and placing requests to other connection managers on the local user's behalf. During conference setup, a connection manager first communicates remotely with peer connection managers via CCP, then communicates locally with the media agents via well-defined call interfaces to actually create the underlying voice, video and groupware data flows.

The CCP specification emphasizes the connection establishment and disconnection procedures. A main task is the four-phase conference setup process. During conference setup, the initiator is responsible for negotiating a common set of capabilities, requesting participation, initiating media connections and propagating information among peers; it acts as a leader until conference creation completes. With the conference in place, the initiator reverts to having no special status, and other sites may be invited, join or leave the conference at any time. When a participant disconnects, the rest of the conference is left intact, unless it was a two-party connection which would be torn down entirely.

Because functionality may vary greatly between teleconferencing implementations, the protocol must be extensible. Thus, the CCP has a built-in mechanism that acts as a transparent conduit for other types of operations between user interfaces and media agents. These operations might occur during or outside of a conference, without CCP having to know the particulars of each operation. An example would be a media-specific function (e.g., mute a particular audio stream).

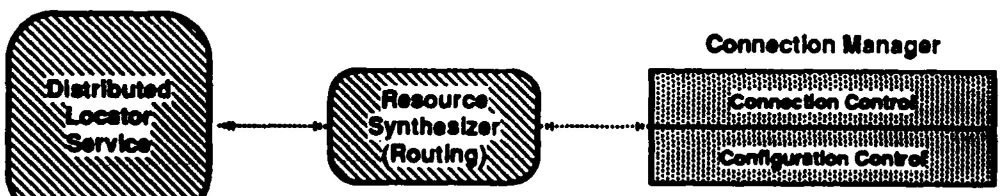
Due to the distributed nature of the system, cooperating connection managers may get out of synchronization. Site A thinks it is conferencing with site B, but site B thinks it is not in conference at all. CCP counteracts these problems by exchanging state information with every message, triggering active state queries, and using a resynchronization algorithm to resolve state mismatches.

4 Configuration Management

Gaging from our own experience with WAN conferencing, as the number of sites scales up, so does the likelihood for heterogeneity among them. When telecollaboration becomes popular over the Internet, users and their equipment will inevitably fall into different administrative domains. Decisions on codec types, bounds on network bandwidth, the number of cameras connected, etc., will be made by different individuals. One end system's *capabilities* or *configuration* is likely to vary from another. Therefore one of the connection manager's functions is *configuration management* — the need to communicate configuration information and to implement service selection (on demand) so that end systems supporting different combinations of services can still be interoperable in the subset of compatible services. Although we are in the beginning stages of the configuration management design, we propose several mechanisms to deal with heterogeneity: a configuration language, a distributed resource locator service, and a resource synthesizer.

A *configuration language* must be developed to describe resources and devices located at each end system. This language will categorize the set of services offered by each system, and must be extensible to accommodate new services and devices as they are added. The system will maintain a mapping of configuration attributes to media agents, allowing the connection manager module to choose an appropriate agent or agents to meet configuration requirements made by applications. This is crucial for the negotiation phase of the CCP connection establishment procedure.

We also expect to support the dynamic configuration of shared resources so that multimedia devices could be shared among users or applications. For example, a crossbar switch or video codec might be shared among users on a LAN, or devices such as video bridges or coding translators might be remote services available to users throughout the Internet. The system will also provide a procedure for devices, resources and agents to register themselves as available to be shared and will define a *distributed locator service* to provide resource directory functions — the resource description, its location in the network, and the associated configuration parameters.



Dynamic Configuration Management of Shared Resources

In those instances where capabilities at end systems mismatch entirely (i.e., no compromise configuration can be found), a *resource synthesizer* will synthesize solutions to configuration requests [13]. The resource synthesizer must find a sequence of communication mechanisms and intermediate translators to construct paths among all the end systems in the connection. The resource synthesizer would draw information from the locator service about shared capabilities that could be used throughout the network. We expect that experience from the network routing domain will be applicable to this problem.

5 Future Work

A strategy to bring widespread teleconferencing to the Internet community must include an open connection management architecture. That architecture must address issues in heterogeneous configurations and reliability across wide area networks. The blueprints for just such a framework have been outlined in this abstract and we are now turning our efforts toward its implementation.

6 Acknowledgment

This research is sponsored by the Defense Advanced Research Projects Agency under Contract Number DABT63-91-C-0001. The views and conclusions in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency of the U.S. Government.

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